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AUTOMATIC DETECTION OF FADE-IN AND FADE-OUT IN VIDEO SEQUENCES

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ABSTRACT

A common video indexing technique is to segment video shots by identifying scene changes and then to extract features. This paper discusses a novel algorithm for detecting fade-in and fade-out using statistical features of both luminance and chrominance signals. The ratio between incremental change in the mean of the luminance signal to the chrominance (average sum of C_r and C_b) is considered to identify fade-in and fade-out. Results show that the algorithm is capable of detecting all fade regions accurately even the video sequence contains other special effects.

1. INTRODUCTION

A major feature required in a visual information system is an efficient indexing technique to enable fast access to the stored data. A video index serves as a descriptor of the video, thus enabling rapid access to the video clips stored in a multimedia databases. Another consideration is that a user who is interested in searching, browsing or retrieving video clips needs a way to interface with the database by formulating appropriate queries. These queries need to be appropriately translated into a form that can be used to search index and retrieve the matching clips. A typical approach to indexing and archiving video for retrieval requires parsing the video, extracting key information from each clip, indexing the information and providing a representation which allows accurate and efficient retrieval based on the user's request. A common technique is to index the video sequences first into video shots by identifying scene changes and then to extract features. Scene changes (transitions) can be divided into two categories: abrupt transitions and gradual transitions. Gradual transitions include camera movements: panning, tilting, zooming and video editing special effects: fade-in, fade-out, dissolving, wiping.

Considerable work has been done for automatic sudden change detection and camera movements [1-4]. However, automatic special effect detection is still in a very early stage. Zabih et al [5] proposed a feature-based algorithm for detecting fade-in and fade-out detection. This algorithm needs to detect edges in every frame and hence it is very costly. Another limitation of this scheme is that the edge detection method does not handle rapid changes in overall scene brightness, or scenes, which are very dark or very bright. Furthermore, automatic segmentation and classification is not possible with this scheme. Alattar proposed an algorithm for detecting fade-in and fade-out by exploiting the semi-parabolic behaviour of the variance curve [6]. This algorithm can only detect fade-in and fade-out when the sequence is frozen. When the sequence has considerable motion, this algorithm fails to identify correct fade-in and fade-out regions. In this paper a real time algorithm is proposed for fade-in and fade-out detection using the statistical features of both luminance and chrominance signals.

The paper is organised as follows. Section 2 gives a brief introduction to fade-in and fade-out and their mathematical analysis. Section 3 describes the proposed algorithm. Results are presented in section 4. Section 5 includes the conclusions.

2. FADE-IN AND FADE-OUT

In video editing and production, proportions of two or more picture signals are simply added together so that the two pictures appear to merge on the output screen. Very often this process is used to move on from picture A to picture B. In this case, the proportions of the two signals are such that as the contribution of picture A changes from 100% to zero and the contribution of picture B changes from zero to 100%. This is called dissolving. When picture A is a solid colour, it is called as fade-in and when picture B is a solid colour, it is known as fade-out. Consider a sequence, which is

subjected to fade-in. Mathematically, fade-in can be expressed as shown in Equation (1).

$$S_n(x, y) = \begin{cases} f_n(x, y) & 0 \leq n < L_1 \\ \left[1 - \left(\frac{n-L_1}{F}\right)\right] C + \left[\frac{n-L_1}{F}\right] g_n(x, y) & L_1 \leq n < (L_1 + F) \\ g_n(x, y) & (L_1 + F) \leq n \leq L_2 \end{cases} \quad (1)$$

Where, $S_n(x, y)$ - Resultant video signal, $f_n(x, y)$ - Picture A, $g_n(x, y)$ - Picture B, C - Video signal level (solid value) at the start of the fade-in sequence, L_1 - Length of sequence A, F - Length of fading sequence, L_2 - Length of the total sequence.

Assume that video sequence $f_n(x, y)$ and $g_n(x, y)$ are ergodic with mean m_f and m_g , and variance σ_f^2 and σ_g^2 . Let, $m_{s,n}$ is the mean of the resultant video sequence S_n and $\sigma_{s,n}^2$ is the variance of the resultant video sequence.

$$m_{s,n} = \begin{cases} m_f & 0 \leq n < L_1 \\ C + \frac{L_1}{F}(C - m_g) - \frac{n}{F}(C - m_g) & L_1 \leq n < (L_1 + F) \\ m_g & (L_1 + F) \leq n \leq L_2 \end{cases} \quad (2)$$

$$\sigma_{s,n}^2 = \begin{cases} \sigma_f^2 & 0 \leq n < L_1 \\ \left[\frac{\sigma_g^2}{F^2}\right] [n^2 - 2L_1n + L_1^2] & L_1 \leq n < (L_1 + F) \\ \sigma_g^2 & (L_1 + F) \leq n \leq L_2 \end{cases} \quad (3)$$

Taking the mean shows that during fade-in the mean has a linear characteristic as given by Equation (2). Furthermore, the variance has a quadratic behaviour as shown in Equation (3).

It should be noted that all these mathematical derivations are valid under the assumption of the video sequences are an ergodic process. However in practice this is not true and alternative strategies are needed in order to identify these special effects.

3. PROPOSED SCHEME

During special effects like fade-in and fade-out large movements between frames are not allowed as it causes inconvenience to the viewer and also it leaves a rough

transition between the two scenes. However, still the process is not an ergodic process. Therefore, fading cannot be detected using only the linear behaviour of mean and the quadratic behaviour of variance as these parameters are very sensitive to even for a small motion. Since video signal consists of a linear combination of luminance (Y) and two chrominance (C_r and C_b) signals, similar set of equations can be derived for both luminance and chrominance signals. Mean of the chrominance signal is not sensitive as mean of the luminance signal for a video sequence. However, for a fading sequence both signals are equally sensitive. We combine this behaviour of the chrominance signal together with the luminance signal to identify fading. Since mean of the two signals have a linear characteristic during fading, the ratio (" $R(n)$ ") of incremental change in the mean of the luminance signal to the chrominance signal (average sum of C_r and C_b) should be a constant during a fading sequence (Equation - 5 and 6). During a non-fading sequence incremental change in the mean of the chrominance signal is small compared to the luminance signal. Therefore, naturally ratio $R(n)$ should have a larger variation.

In this proposed scheme, we exploit the linear behaviour of the mean and zero variance at the beginning of fade-in process (variance is zero at the end of the fade-out process). It can be shown that the change in mean of the video signal can be expressed as in Equation (4).

$$|E[S_{n+1}] - E[S_n]| = \begin{cases} \Delta_n & 0 \leq n < L_1 \\ \left[\left(\frac{1}{F}\right)(C - m_{n+1} + (L_1 - n)\Delta_n)\right] & L_1 \leq n < (L_1 + F) \\ \Delta_n & (L_1 + F) \leq n \leq L_2 \end{cases} \quad (4)$$

where, $\Delta_n = |m_{n+1} - m_n|$.

$$R(n) = \frac{|E[S_{n+1}^Y] - E[S_n^Y]|}{|E[S_{n+1}^C] - E[S_n^C]|} \quad (5)$$

$$R(n) = \begin{cases} \frac{\Delta_n^Y}{\Delta_n^C} & 0 \leq n < L_1 \\ \frac{|C - m_{n+1}^Y + (L_1 - n)\Delta_n^Y|}{|C - m_{n+1}^C + (L_1 - n)\Delta_n^C|} & L_1 \leq n < (L_1 + F) \\ \frac{\Delta_n^Y}{\Delta_n^C} & (L_1 + F) \leq n \leq L_2 \end{cases} \quad (6)$$

where, S_n^C - Chrominance Signal
 S_n^Y - Luminance Signal
 Δ_n^C - Incremental change in mean of the chrominance signal
 Δ_n^Y - Incremental change in mean of the luminance signal

Simulation results confirmed that the ratio of $\left[\frac{\Delta_n^Y}{\Delta_n^C} \right]$ has a large variance and hence the differentiation of “ $R(n)$ ” should also have a larger variance. During a fade-in sequence, however “ $R(n)$ ” is almost a constant or varying very slowly with reference to the non-fade-in case. As a consequence, differentiation is close to zero and enables to detect fade-in regions.

$$D_R = \text{abs}(R(n) - R(n-1)) \quad (7)$$

Therefore, considering the absolute value of the differentiation as defined in Equation (7), it is possible to detect the fade regions by setting a very low threshold (T_{fade}). It may be possible to satisfy the condition ($D_R < T_{fade}$) for a small number of consecutive frames in a non fade-in sequences. But, small size of fade-in sequences are not common in practice and also there should be a frame with zero variance either at the beginning or at the end of the detected region. Using this argument false regions are eliminated from the proposed algorithm. Furthermore, if there are two consecutive fade regions separated by very small gap, they are bridged to form a longer fade region.

Similar set of equations and arguments can be derived easily for fade-out with the initiative function in Equation (8). Finally, algorithm identifies the fade-in and fade-out as follows.

$$S_n(x, y) = \begin{cases} f_n(x, y) & 0 \leq n \leq L_1 \\ \left[1 - \left(\frac{n - L_1}{F} \right) \right] f_n(x, y) + \left[\frac{n - L_1}{F} \right] g_n(x, y) & L_1 < n \leq (L_1 + F) \\ g_n(x, y) & (L_1 + F) < n \leq L_2 \end{cases} \quad (8)$$

Fade-in: Detect a frame with zero variance followed by a sequence of continuous region, which is identified by D_R .

Fade-out : Detect a sequence of continuous region, which is identified by the above algorithm followed by detecting a frame with zero variance.

4. SIMULATION RESULTS

Consider a test sequence to describe the performance of the above algorithm. Figure 1 shows mean of the luminance signal for a test sequence. The same information for chrominance signal is presented in Figure 2. Figure 3 shows the function D_R for the sequence. Figure 3 reveals that there is a region, which satisfies the condition ($D_R < T_{fade}$), right after the 21st frame. Thus, the fading region is identified from 21st frame to 70th frame. However, variance of the 21st frame is zero. Therefore this identifies the fade-in sequence accurately.

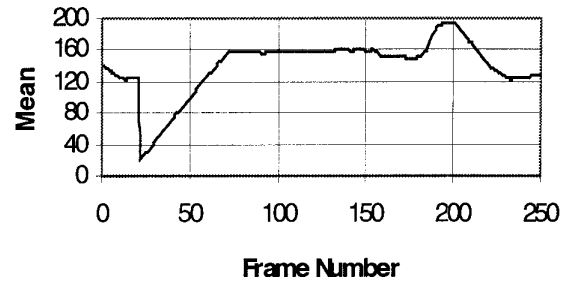


Figure 1: Mean of the luminance signal of the test sequence

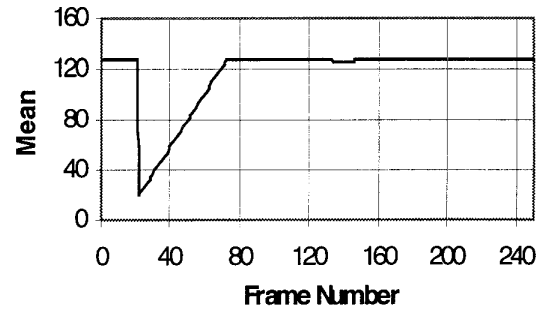


Figure 2: Mean of the chrominance signal of the test sequence

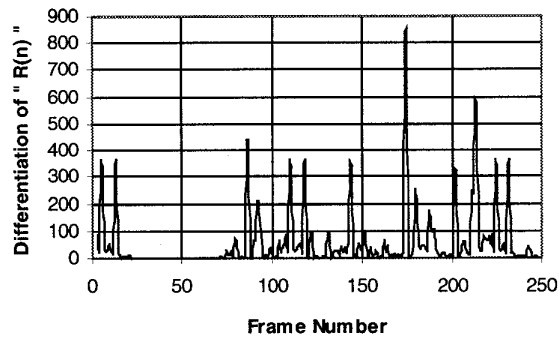


Figure 3: Differentiation of $R(n)$ (D_R) for the test sequence ($T_{fade} = 5$)

Sequence	Actual fade region	Detected fade region	Nature of the region
1	21-70	21-70	fade-in
	299-337	299-337	fade-in
	348-403	348-403	fade-out
	444-546	444-546	fade-out
	595-667	595-668	fade-out
2	44-86	44-87	fade-in
	302-467	302-467	fade-out
	565-620	565-620	fade-in

Table 1: Summarised results for two different sequences

Sequence 1: Length of 700 frames and contains two fade-in and three fade-out regions. This sequence doesn't contain either any other special effects or sudden scene changes.

Sequence 2: Length of 700 frames and contains one fade-out regions, two fade-in regions, two sudden scene changes, and several other special effects like zoom-in, zoom-out, panning and tilting.

Table 1 shows the summarised results of the proposed algorithm with the above two sequences. Results show that the algorithm is capable of detecting all fade regions accurately even the video sequence contains other special effects. However, this algorithm may fail to identify fading regions when the solid colour is very close to the mean of the original sequence (before fading is applied).

5. CONCLUSIONS

The ratio between incremental change in the mean of the luminance signal to the chrominance signal (average sum of C_r and C_b) is considered as the criteria of identifying fading transitions. Results show that the algorithm is capable of detecting all fade regions accurately even the video sequence contains other special effects. Therefore, the proposed algorithm can be used in uncompressed video to detect fade-regions with a very higher reliability rate. Further work is required to extend this algorithm for compressed video.

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